RTI Hotspot Mapping and Analyzing the Trends

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Global and Regional Burden of RTIs

Road Traffic Injuries Are The Leading Cause Of Death Among Young Adults Aged 18-24 Worldwide

Low- And Middle-Income Countries (LMICs) Face A Disproportionate Burden Due To Poor Infrastructure, Weak Enforcement, And Limited Emergency Care

Punjab, Pakistan Accounts For Over 56% Of The National Road Network And Faces Rising RTI Risks Amid Rapid Road Expansion

Infrastructure Quality, Population Density, And Pedestrian Safety Strongly Influence Regional RTI Rates

Engineering Solutions Like Improved Road Design And Speed Regulation Reduce RTIs But Require Precise Hotspot Identification For Effective Targeting

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Punjab EMS: Overview and Study Scope

Punjab is Pakistan's most populous province with **128 million** residents

Rescue 1122, initiated in 2004, is Pakistan's largest EMS agency

Agency pioneered deployment of trained **Emergency Medical Technicians (EMTs)**

Emergency calls placed via **1122 hotline** to dispatch nearest ambulances to road traffic incidents

Mild injuries treated on-site with first aid; severe injuries transported to hospitals

Retrospective study analyzes EMS records from **2022-2023**, covering pre-hospital care for RTI victims

Data provides detailed insights into spatial and demographic patterns across Punjab's **41 districts**

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Spatial Mapping of RTI Risk Zones through GIS

Data Input

Collect and prepare RTI occurrence data as the foundation for spatial analysis.

Hotspot Analysis

Apply Getis-Ord Gi* statistics to detect statistically significant clusters of high (hotspots) and low (cold spots) RTI densities.

Buffer Overlay

Create 20-meter radius buffers around roads to spatially assign RTIs based on average highway widths.

Hotspot Identification

Integrate hotspot and buffer results to pinpoint priority road segments for intervention and resource allocation in road safety management.

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Key Variables and Logistic Regression Analysis

Extracted variables: demographic (age, gender, education), injury characteristics, victim type, response, and elapsed times

Primary outcome: on-scene mortality analyzed using logistic regression

Education levels dichotomized for regression modeling

Calculated crude and adjusted odds ratios to assess key predictors

Applied rigorous statistical methods using R

Comprehensive variable inclusion strengthens analytical validity

Demographic and Injury Profile of EMS-Transported RTI Patients

Key insights into patient demographics, injury types, and EMS care in LMIC contexts

Among 237,861 EMS-transported RTI patients, **82.58% were males** and **56.44% aged 18–40 years**

Most patients had education up to intermediate or below (**84.6%**), indicating vulnerable socioeconomic status

Injuries were primarily **external (77.42%)**, including cuts and abrasions, followed by fractures and head injuries

Patients represented varied professions, notably **farmers, housewives (13%)**, and **students (16.85%)**

First aid was administered onsite to 57.51%, while **41.80% were transported to hospitals** for further care

These patterns reveal vulnerable groups and common injury severities typical in low- and middle-income countries

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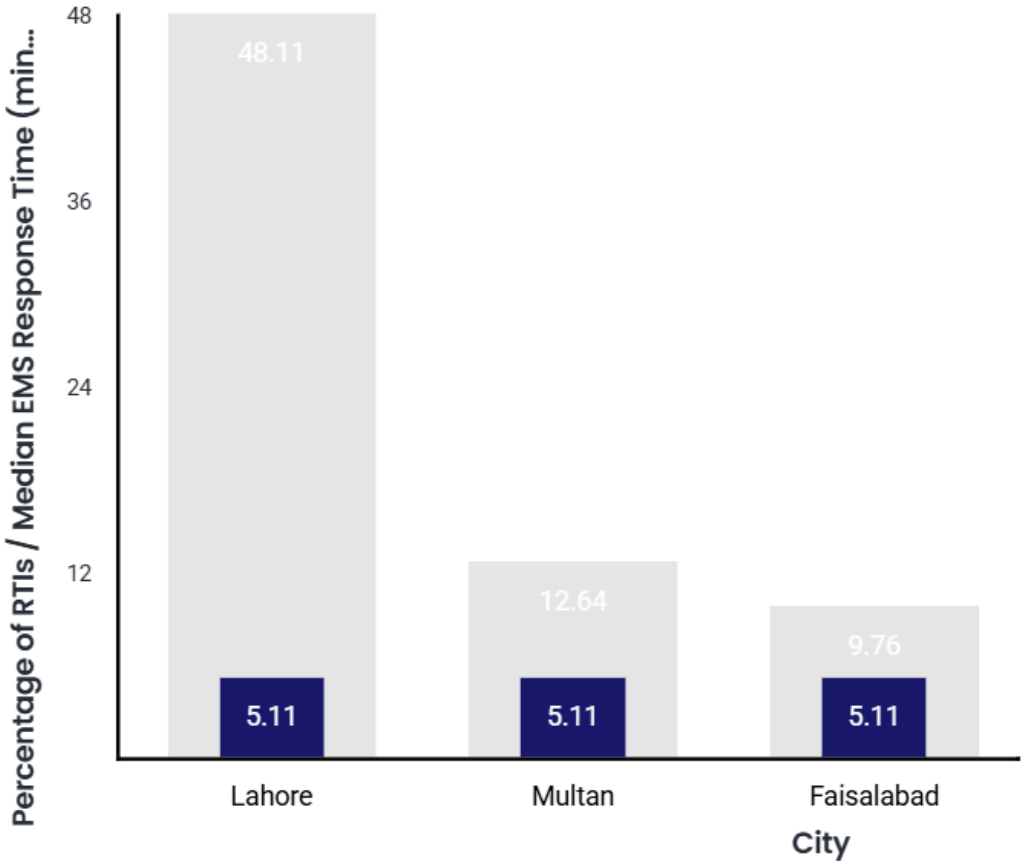
Analyzing Regional Injury Distribution and Response Time



Median EMS response time was 5.11 minutes (IQR 3.21–8.15), comparable to some high-income countries despite resource constraints

Longer EMS response times are significantly associated with increased on-scene mortality as shown by logistic regression analysis

RTI hotspots align with urban centers due to higher population density and increased EMS usage

Findings highlight the critical impact of targeted EMS deployment to high-risk regions to improve survival outcomes

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Lahore: Analyzing RTIs by Age, Role and EMS Response Time

Road Name	RTIs Reported	Predominant Age Group (%)	Victim Role (%)	First Aid Onsite (%)	Avg. Response Time (min)	Correlation with Mortality
Allama Iqbal Road	45,160 (total among top 10)	18–39 (57.4%), Under 18 (16.9%)	Drivers (48.95%)	60.1	3.86	Lower mortality (shortest response)
Lahore Ring Road	Included in total	18–39 (57.4%), Under 18 (16.9%)	Drivers (48.95%)	60.1	6.75	Higher mortality (longest response)

01 Total 45,160 RTIs concentrated on top 10 roads with young adults (18–39) most affected (57.4%)

02 Victims primarily drivers (48.95%), receiving first aid onsite in 60.1% of cases

03 EMS response times vary by route: fastest 3.86 min on Allama Iqbal Road, slowest 6.75 min on Lahore Ring Road

04 Longer EMS response times correlate with increased mortality, highlighting urgent need for targeted infrastructure and EMS upgrades

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Interpreting RTI Hotspots and EMS Impact in Punjab

Leveraging EMS data and GIS to pinpoint high-risk zones and improve emergency outcomes

01 Identification of RTI Hotspots

- Lahore, Multan, and Faisalabad are confirmed as high-incidence RTI areas using EMS and GIS data
- Spatial epidemiology supports targeted resource allocation and injury prevention efforts

02 EMS Response and Mortality Outcomes

- Shorter EMS response times significantly reduce on-scene mortality in RTI cases
- Punjab's EMS response is notably more efficient than in comparable low- and middle-income countries

03 Implications for Policy and Practice

- Focusing EMS improvements on identified hotspots could further reduce fatalities
- Integrating spatial data with EMS operations provides a foundation for effective injury prevention strategies

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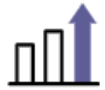
Targeted EMS Strategies to Cut Response Time

Optimize EMS deployment by prioritizing coverage on identified high-risk road segments to minimize response times and lower mortality rates

Implement motorcycle ambulances alongside traditional ambulances to improve accessibility and reduce arrival times in traffic-congested or difficult terrains

Leverage spatial hotspot data to strategically allocate resources and enhance emergency care efficiency in low- and middle-income country contexts

Integrate EMS planning with road safety policies by combining infrastructural improvements and adaptive EMS capabilities to effectively reduce the road traffic injury burden



Encourage policymakers to embed spatial and EMS data analytics into ongoing road safety and emergency response frameworks for sustained impact

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Identified **Lahore, Multan, and Faisalabad** as primary RTI hotspots using EMS data and spatial analysis

EMS average response time is **5.11 minutes**, demonstrating strong baseline performance with room for improvement in hotspot zones

Future studies should investigate **underlying causes** of localized RTI clusters to inform targeted interventions

Incorporate **patient outcome tracking** to improve injury prevention strategies and EMS system responsiveness in LMIC contexts

Overall, findings support continuous EMS optimization and data-driven policy development for safer roads in Punjab

DATA IS POWER

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